Robert L. Bates

JOURNAL

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GEOLOGICAL EDUCATION

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The Association of Geology Teachers
October, 1953

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I N M E M O R I A M

RALPH E. DIGMAN

Assistant Professor of Geology, Harpur College

President, Eastern Section, A.G.T., 1950-51
National Secretary, A.G.T., 1951-53

A devoted and successful teacher

Died of polio complicated by pneumonia

December 20, 1953

THE JOURNAL OF GEOLOGICAL EDUCATION

The Journal of Geological Education is published semiannually by the Association of Geology Teachers. Publication dates are April and October. The annual subscription price is $2.00. Single issues are $1.15.

Subscription payments and correspondence should be sent to the national treasurer of the Association of Geology Teachers: Dr. Gerald M. Friedman, Dept. of Geology and Geography, Univ. of Cincinnati, Cincinnati 21, Ohio.

The editor of this issue is Dr. William F. Read of Lawrence College, Appleton, Wis. The editor of the next issue will be Dr. Anastasia Van Burkalow of the Dept. of Geology and Geography, Hunter College, 695 Park Ave., New York 21, N.Y. All future correspondence regarding material to be published in the Journal should be sent to the new editor.

The Editorial Committee for the Journal consists of the Journal editor, the editors of each of the regional sections of the Association of Geology Teachers, and the national treasurer.

All persons interested in geological education are invited to subscribe and contribute to the Journal.

THE ASSOCIATION OF GEOLOGY TEACHERS

The Association of Geology Teachers is a national association of persons interested in the advancement of earth science education "at all levels of formal and informal instruction". There are regional Sections of the Association in various parts of the United States. For information regarding membership, address the national secretary, Dr. Milton T. Heald, Dept. of Geology, University of West Virginia, Morgantown.

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EDITORIAL

The constitution of the Association of Geology Teachers, as amended April 1, 1953, fixes the normal term of appointment of the Journal's editor at three years. New editors are appointed by the Executive Committee of the Association, consisting of the elected officers (president, vice-president, secretary, and treasurer), the last past-president, and one representative from each Section of the Association.

The writer has now completed his three-year term. The new editor, as announced in the December, 1953, Transactions of the Association of Geology Teachers, is Dr. Anastasia Van Burkalow of Hunter College in the City of New York.

Miss Van Burkalow received her bachelor's degree from Hunter in 1931. As a graduate student at Columbia, she had the good fortune to study under William Morris Davis and Douglas Johnson. She received the master's degree from Columbia in 1933. For the next three years she worked as Dr. Johnson's research assistant, one of her principal duties being the abstracting of geomorphic literature—not only in English, but also in French and German. In 1937-38 she was awarded the Kemp Fellowship at Columbia, and under Professor Johnson's direction began an experimental study of factors affecting angle of repose and angle of sliding friction.

In 1938 she joined the teaching staff at Hunter College. In 1944, having completed a dissertation on the angle of repose experiments,[1] she was awarded the doctor's degree by Columbia.

During the interval 1945 to 1948 she gave up teaching to become a reasearch assistant with the American

[1] Bulletin of the G.S.A., Vol. 56 (1945), pp. 669-708.

Geographical Society. One of her projects in this connection was a study of fluorine in U.S. water supplies[2]. She also did some writing and a good deal of editing for the Geographical Review, and for various special publications of the Society.

In 1948 she returned to Hunter College, where she is now an assistant professor. Her current geological interests include work on heavy minerals for the Du Pont Company, while, on the geographical side, she continues as a contributing editor for the Geographical Review. She is a member of the G.S.A. and the American Geophysical Union, and a fellow of the New York Academy of Sciences.

Miss Van Burkalow is eminently qualified to serve as editor of the Journal of Geological Education. The Association of Geology Teachers is fortunate to have secured a person of her capabilities. We may be sure of one thing: Miss Van Burkalow is deeply and genuinely interested in the advancement of geological education or she would not have accepted the job. The Journal editor serves long hours without pay.

My own experience as editor during the past three years has been a rewarding and satisfying one. If the Journal has gotten off to a good start, it is because my fellow teachers have supported it generously with their subscriptions, nurtured it with excellent manuscripts freely given, and borne with unfailing equanimity the shortcomings of an editor not too adept at the trade. I can wish for my successor no greater blessing than that her efforts will continue to be supported, as mine have been, by the good will of all who would like to see "more people taught more geology better".

William F. Read

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[2]Geographical Review, April, 1946

NOTES AND NEWS

National Association. The third annual meeting of the National Association of Geology Teachers was held at Toronto, November 9, 1953, in conjunction with the annual meeting of the Geological Society of America. About sixty members were present. Dr. David M. Delo, the retiring president, opened the program with an address on "Cooperation among the Geological Sciences". He then introduced the recipient of the Neil A. Miner Award, Fritiof M. Fryxell of Augustana College, citing Dr. Fryxell's outstanding contributions to the advancement of geological education. In response, Dr. Fryxell spoke on "The Estate of Teaching in Geology". Dr. Delo's introduction, Dr. Fryxell's response, and a facsimile of the award itself, are printed in this issue of the Journal.

Highlights of the business meeting which followed were (1) announcement of new national officers for 1954, elected by mail ballot:

President -- Leland Horberg, Univ. of Chicago
Vice-Pres.-- John B. Lucke, Univ. of Connecticut
Secretary -- M. T. Heald, Univ. of W. Virginia
Treasurer -- G. M. Friedman, Univ. of Cincinnati

(2) election of three members-at-large to the Neil A. Miner Award Committee for 1954: Charles H. Behre, Jr., of Columbia University, Joe W. Peoples of Wesleyan University, and Alfred O. Woodford of Pomona College. (3) announcement of the election of Prof. A. C. Trowbridge of the University of Iowa to honorary membership. (Honorary members have all the rights and privileges of ordinary members, but pay no dues. They are elected by unanimous vote of the Executive Committee of the National Association.)

Following the business meeting, there was a "colored slide symposium" at which various members exhibited their best slides and took orders for duplicates.

N.S.F. Conference on Research in Small Geology Departments. From October 30 to November 1, 1953, Beloit College of Wisconsin was host to a conference of representatives of small geology departments sponsored by the National Science Foundation. The purpose of the conference was to discuss the role of the small department in promoting geological research and to offer recommendations as to how small departments might function more effectively in this regard. Plans for the conference were drawn up by a steering committee consisting of J. W. Peoples, Wesleyan University, chairman; F. M. Fryxell, Augustana College; O. T. Brown, Mississippi Southern College; and A. O. Woodford, Pomona College. Twenty-seven teachers selected from institutions varying widely in size, type, and location attended the sessions at Beloit.

The group was divided into five panels to draw up preliminary recommendations in regard to (1) actual research (2) scholarships (3) field training (4) equipment, and (5) library resources. The panel recommendations were then submitted to the entire conference for discussion and modification, after which they were rewritten by the various panels meeting separately.

After the close of the conference the revised panel recommendations, plus an introduction and summary, were assembled by the steering committee into a preliminary report. This was distributed by mail to all conferees for further modification and correction. The final report of the conference, to be published soon, will be the result of this remarkably democratic procedure. A last draft is currently being prepared by the steering committee.

Boy Scout Merit Badge in Geology. The Newsletter of the American Geological Institute has repeatedly called attention to the new booklet on "Geology" in the Boy Scout merit badge series. (This booklet, published in January, 1953, is available from the Boy Scouts of America, 2 Park Ave., New York 16, N.Y.,

for 25 cents. Copies may also be secured at many local Scout offices.)

Everyone interested in geological education should be familiar with it. As a brief, inexpensive, well-illustrated, authoritative presentation of the major aspects of geological science, it is the ideal answer to the long bothersome question--what to recommend for the interested layman, young or old, who wants a book that will tell him "a little something" about rocks, minerals, caves, mountains, or whatever else has caught his fancy.

The list of "Interesting Books on Geology" at the end of the booklet suggests titles that many a college professor will want to recommend to his students (after he has stayed up all night reading the books himself).

But the most important use of the booklet is, of course, the one for which it was intended. It provides background information which Boy Scouts must understand and apply in order to carry out certain specific projects required for the Geology merit badge. What are these projects? First, the Scout must make a collection, properly labelled and explained, of various ores, minerals, rocks, or fossils. Second, he must study a mine, gravel pit, quarry, or oil field and report on its geological and economic aspects. Third, he must make a pace and compass map of an area covering at least one square mile--indicating and identifying rock outcrops. And fourth, he must complete some other special project involving a knowledge of geological facts and methods different from those required for the completion of the other three projects.

Despite the excellence of the background material presented in the booklet, it is quite evident that the requirements outlined above put a very large burden of responsibility on the "merit badge counselor". Without expert guidance and encouragement from a trained geologist familiar with the local scene, even

the most enthusiastic and intelligent young Scout is almost certain to bog down on any one of the projects outlined above. He most certainly could never complete all four of them. It is evident therefore, as the A.G.I. repeatedly reminds us, that it is up to each geologist to undertake the responsibility of counselling in his own area if he wants to see Boy Scouts earning the Geology merit badge. It is further evident that the geologist must take the initiative. He must go to the Scouts and show them that the projects required by the merit badge can be done, and that the work will be interesting. He must offer specific suggestions as to where the specimens required for the collection may be found; what mines, quarries, etc. in the vicinity are suitable subjects for a report; which square miles offer the best possibilities for mapping; and what other geological projects a Scout might choose from to satisfy the fourth requirement. In short he must sell Scouts on the idea of going out for the Geology merit badge.

The ultimate good which may result to the science if individual geologists wholeheartedly support the Scout merit badge program can hardly be overestimated. We are all agreed in lamenting the fact that routine public school education of the citizens of tomorrow involves practically no serious contact with geology. Here is an opportunity to rectify in part this serious deficiency in our educational system. As the twig is bent, so grows the tree. It is a reasonably sure prediction that more than one Scout who is encouraged to work for the merit badge in Geology this spring will be a leader in the profession thirty years hence. It is a certainty that every Scout who works for the badge will go through life with a better understanding of what geology, and geologists, are all about.

Analysis of Published Opinions on the Training of Geologists. Professor Claude C. Albritton, Jr., of Southern Methodist University has recently published in Field and Laboratory (Vol. 21, No. 1; June, 1952; pp. 13-20) an excellent analysis of published opinions on the training of geologists, beginning with the

report of the Committee on College Curricula of the American Association of Petroleum Geologists, dated 1942, and ending with the report on "The Geology Curriculum in the Liberal Arts College" by a joint committee of the Geological Society of America, the Association of Geology Teachers, and the American Geological Institute, dated 1950. The title of his paper is "Historical Approach to the Problem of Training Geologists". Dr. Albritton recognizes two distinct schools of thought regarding the training of geologists: the liberal, and the vocational or technical. He suggests that the only satisfactory way to judge the relative merits of the two types of training is by a study of the subsequent accomplishments of students subjected to each type. With this purpose in mind he summarizes the accomplishments of 228 geologists graduated from Southern Methodist University since 1915. Dr. Albritton regards these men and women as products of a distinctly liberal type of training.

High School Lectures sponsored by Universities of Wisconsin and Minnesota. The November, 1953, issue of the A.G.I. Newsletter calls attention to a unique effort to interest pre-college students in geology through their assembly programs. Dr. George A. Thiel of the University of Minnesota is credited with originating the idea. It is sponsored, officially, by the Extension Divisions of the University of Wisconsin and the University of Minnesota. Mr. William A. Black, a graduate student in geology at the University of Wisconsin, has been employed on a full-time basis to lecture at high school, and junior high school, assemblies in the two states. He normally lectures only once at a given school. Speaking on the subject "Our Restless Earth", he explains the origin of earthquakes and how information is gained from them about the deep interior of the earth. This leads to a discussion of artificially generated earthquakes and their application to the search for petroleum. According to the A.G.I. Newsletter, the program will be continued next year under the joint sponsorship of the University of Minnesota and the University of

Kansas.

Conference on Earth Science Teaching held at Bowling Green State University. In November, 1953, the Departments of Geography and Geology at Bowling Green (Ohio) State University jointly sponsored a one-day conference for earth science teachers in nearby schools. Speakers included a representative of the Ohio State Survey, professors of geology and geography from Bowling Green and other universities, professors of science education, and earth science teachers from a variety of high, and junior high, schools. It is planned that similar conferences will be held in future years. In addition, there will be spring and fall field excursions for the teachers and other interested persons.

Professor John R. Coash of the Department of Geology at Bowling Green described the inception of this conference in a paper entitled "Recent Projects at Bowling Green State University" presented at the first annual meeting of the East Central Section of A.G.T. April 10, 1953, (see page 3 of the April, 1953, issue of the Journal). Mr. Coash's comments on his department's efforts to stimulate interest in earth science in the local schools were then as follows:

"Most of our projects have been quite informal. We have simply gone to local city and county schools to talk to the teachers and children. Either we were asked to come, or we persuaded someone to ask us. Occasionally we were able to help with geological collections. When schools had their Science Day programs we made a special effort to contact students who were doing outstanding work in their science courses.

"In January we asked Mr. Walter C. Brown of the Ohio Geological Survey to speak at an open house meeting to which we invited science teachers from local high schools. Despite Mr. Brown's fine contribution, the response to this experiment was not particularly gratifying. Apparently the senior high

school teachers, for the most part, were just not interested in our field of science. The junior high teachers were more interested, but most of them indicated that, due to inadequate training, they tended to skim very lightly over the earth science unit in their general science courses.

"In a follow-up letter to these teachers, we gave them our reasons for the effort to create interest in earth science and told them specifically what we were willing to do to help out. We offered our services as lecturers, discussion leaders, career counselors, and field trip guides. We listed slides, maps, movies, and specimens which we were willing to lend. We called attention to courses they could take with us to improve their background in earth science.

"Finally, in an effort to help these teachers further, we have made plans for a conference on the teaching of earth science to be held at Bowling Green State University early in November, 1953."

Those of us who recognize the desirability of effective geological instruction at the pre-college level, but who personally do little about it, must certainly take off our hats to Mr. Coash and his colleagues.

TRIBUTE TO F. M. FRYXELL, RECIPIENT OF NEIL A. MINER AWARD, 1953[1]

David M. Delo
Retiring President, A.G.T.

The Neil A. Miner Award was established by the Association of Geology Teachers in 1952 to recognize the achievements of individuals who have contributed beyond the call of duty to the teaching of geology and to the dissemination of knowledge concerning the earth sciences.

The award is named for Dr. Neil A. Miner, former professor of geology at Cornell College, one of the founders of the Association, who was cut down by a dread disease just as his career as a distinguished teacher was coming into full fruition.

Establishment of such an award has been long overdue. Now that it has become an actuality, Dr. Fryxell, your fellow teachers could think of no one more pre-eminently worthy of the award than yourself. I view your willingness to accept the award with much personal pleasure as well as official gratification.

For 30 years as a teacher of geology at Augustana College, your alma mater, you have almost single-handedly made a major contribution to the ranks of

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[1]The Neil A. Miner award was presented for the first time at the 1953 annual meeting of the Association of Geology Teachers, held at Toronto, November 10, 1953. Dr. Delo's tribute was addressed to Dr. Fryxell personally, as the award was being presented. Recipients of the Neil Miner Award are nominated by the membership of the Association. Final selection rests with an Award Committee consisting of the Association's president, past-president, and secretary, and three other elected members.

workers in earth science. From your department alone have come more than 100 trained geologists, and the number of these who have received the PhD is higher than from most universities.

It is obvious, from this record, that you have not only fired your students with enthusiasm for your chosen field. You have also instilled in them a love of truth and a desire for research.

Despite heavy teaching schedules and the usual extra-curricular duties with which small college teachers are always burdened, your vitality and production as a scientist have not waned. Your research on the Tetons, on the petroleum resources of the Philippines, and with the Military Geology Unit of the U.S. Geological Survey bear tribute to the excellence of your scientific work. In addition, your efforts strengthened the museum program of the National Park Service in a very material way. More recently you have placed the work of Matthes in the Sierras before the world in beautifully explicable form.

Throughout you have worked continuously for the good of the earth sciences and your colleages in the field. As a founder and president of the Association of Geology Teachers, a director of the American Geological Institute, and an officer of numerous other organizations, you have engaged in the cooperative effort so necessary to the long-range progress of the earth sciences. Fellowship in the Geological Society of America, the American Association for the Advancement of Science, and the American Geographical Society testify to the scope and breadth of your interests.

Throughout you have maintained the humility of a true searcher for scientific truth, the fire and enthusiasm of a great teacher, and the eager interest of a true lover of nature.

Hence, in my capacity as president of the Association of Geology Teachers, and upon unanimous instruction from the Committee on Selection, I present to you the Neil A. Miner Award for 1953.

Association of Geology Teachers

The Neil A. Miner Award

to

Fritiof Nelvin Fryxell

for exceptional contributions to the
stimulation of interest in the Earth Sciences

1953

Secretary President

Facsimile of a preliminary draft

THE ESTATE OF TEACHING IN GEOLOGY[1]

F. M. Fryxell
Augustana College

The limitations of language are never so evident as when one seeks to express gratitude in a way that will sound truly sincere and convincing. I have sought, and sought diligently, for words which might express my deep appreciation of this honor, but I have found none which seemed adequate. There is left no choice for me but to say, in all simplicity, a heartfelt "thank you".

Perhaps I can do better by way of explaining why this award means a very great deal to me:

For one thing, it bears the name of a man whom--in common with some of you--I knew intimately, admired, and loved. I am happy that this award serves as a tribute to Neil Miner--that through it his memory will be kept bright, and his fine ideals held high for the inspiration of others.

Furthermore, this award comes as a gesture from those whose confidence and good will I particularly esteem, the colleagues and co-workers who through the years have become my friends.

Also I gladly recognize that this award has a significance which transcends the personal--that it is primarily the recognition of the service rendered by all those who have, in one way or another, given of their time, effort, and talents to the teaching of the earth sciences. If I may receive this award as a representative of that fellowship I am truly happy to accept it, acknowledging, as I do so, that from our ranks many others might have been chosen just

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[1]Response, on being presented with the Neil A. Miner Award, at the 1953 annual meeting of the Association of Geology Teachers, Toronto, November 10.

as well as I to serve, on this occasion, as a symbol of the cause to which we all are dedicated.

Finally, I rejoice to recognize in this occasion one more forward step in the long-range program of the Association of Geology Teachers. Like President Delo, I had the privilege of being present when the Association was founded in 1938 by a group of college teachers who shared the conviction that there existed a very real need for an organization which would seek, as the constitution of the new group later formally expressed it, "to foster improvement in the teaching of the earth sciences, . . to emphasize the cultural significance of the earth sciences, and to disseminate knowledge in this field to the general public". It is scarcely necessary for me to say that I have followed the affairs of the Association with an interest which has been more than casual, and that I have viewed with great satisfaction the achievement, one after another, of objectives which, I well recall, were once only the aspirations and hopes of a few--men who, to an outsider, might have seemed visionary but for the seriousness which marked their deliberations.

The years 1938 and 1953 span an interval of a decade and a half. This meeting at Toronto is, therefore, an occasion of some significance to the Association--it is its fifteenth anniversary. The infancy of the Association lies far behind it; recently, in its middle 'teens, it seems to have been experiencing its most rapid growth; and now, though still plagued by some of the problems and perplexities which go with awkward adolescence, it confidently anticipates a period not far distant when, with the strength and vigor of maturity, it can take its place by the side of other major organizations which in distinctive and essential ways are serving the earth sciences.

Anniversaries are times for reminiscing (a weakness to which I am prone), but I am spared the temptation to review the first fifteen years of the Association

of Geology Teachers because a comprehensive history[2] was completed recently by one better qualified to write it than I. Let me, however, at least glance back over the pre-War programs of the Association. At these programs, the time was devoted mostly to consideration of a wide variety of educational problems, each of which was introduced by a member who gave a prepared introductory talk and then threw the subject open for round-table discussion. The first meeting of the Association (Augustana, 1938) was devoted primarily to consideration of the objectives of the college geology department, the undergraduate curriculum in geology, the equipment and library of the geology department, and the geology museum and study collections. At the second meeting (Cornell, 1939) consideration was given to visual aids in the teaching of geology, the problem of field courses and field trips, and the research program of the geology teacher. The third meeting (Beloit, 1940) centered about popular and semi-popular books on geology, methods of popularizing geology, the program for the prospective graduate student, and again--that subject of unfailing interest to geology teachers--summer field courses. At the fourth meeting (Lawrence, 1941) the discussion concerned laboratory techniques in elementary and advanced courses, opportunities for women in geology, and the placement of geology majors.

This much of retrospect may serve to illustrate how seriously, in its early formative years, the Association was concerned with its three-fold purposes, and to suggest how intensely practical was its approach to its objectives. Every teacher who attended these meetings had specific and urgent questions; there were problems and more problems, and never sufficient time to consider them to the complete satisfaction of all, or to explore the many ramifications of thought which they opened up.

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[2] "The Association of Geology Teachers--a Janus'-Eye View," by Percival Robertson, Published in this issue of the Journal of Geological Education--Ed.

But if the members came with problems, they left with solutions, or at least constructive suggestions as to where and how solutions might be sought. I recall how eagerly, after these meetings, I would return to my own campus because I brought away with me stimulating ideas I could hardly wait to try out for myself and--what may have been even more important--a new perspective of the significance of college teaching. My colleagues, so some of them have told me, went away in much the same exhilerated frame of mind. Hitherto we had each of us been working, so to speak, in a vacuum--for the most part alone and but dimly aware of the fact that our problems were also the problems of others working on other campuses; and now, of a sudden, the meetings of the Association provided us with the opportunity to see for ourselves how things were being done elsewhere--opportunity, too, for unlimited interchange of viewpoints, for comparison of techniques and objectives, in short for airing, with kindred spirits, problems of concern to us all and with which each of us had, independently and in his own way, been wrestling. To say that these meetings influenced the members for good, and greatly so, would be an understatement; it would probably be more correct to say that their effect was, in many ways, revolutionary.

Then came the Second World War. Fought with bombs, it was itself bomb-like in its impact on the well-laid plans of men and in the way it shattered established orders--in kingdoms and, no less, on campuses. Even if the original membership of the Association had not been scattered, never to be reassembled intact again, the annual spring conclaves which had come to mean so much to us would have had to be discontinued because of the travel restrictions which terminated the meetings of organizations far older and larger than ours. That the Association survived this crisis we owe to the officers of the time, particularly the president, Dr. Percival Robertson, who labored with unflagging zeal to maintain activity throughout the war years and, when peace was reestablished, to help launch the Association on a new and enlarged program.

But I have promised not to make this the occasion for history, and I doubt that further history is needed. The rapid growth of the Association in the post-war years, its reorganization on a regional basis, the establishment of one section after another in different parts of the country, the founding of the Journal of Geological Education--these and related events are of such recent occurrence as to be matters of common knowledge.

When I now glance over the membership list of the Association, and review the reports of its sectional and national meetings, my reaction is that truly the organization has grown and changed almost unbelievably since those early informal meetings in Illinois, Iowa, and Wisconsin. But when I turn to the programs of the sectional meetings it is like encountering old, familiar faces, for they, at least, have not changed much. These programs are not only reminiscent of those of ten to fifteen years ago; but some of the topics presented for discussion are actually identical. Newer members have planned these programs, and the participation, too, has been almost entirely by teachers who joined the Association after the War, yet the programs are essentially the same. Clearly the Association continues to be concerned primarily with the specific, practical questions confronting teachers in their day-to-day work. The needs which the Association sought to meet in the first years of its existence are still the needs of the present. But there is this difference: these needs are now being met at the sectional level.

In this, I suspect, is to be seen not only the pattern of the present, but, to borrow a rather trite phrase, the shape of things to come; for, as long as geology is taught, in every generation teachers will feel the need for gathering periodically with their fellows, in small and intimate groups, to observe how others meet their problems, and to discuss the questions which inevitably and perennially arise concerning laboratory work and field training, study and display collections, choice of texts and manuals, visual

education aids, and departmental budgets--not to forget the difficult and quite inescapable assignment confronting most teachers of presenting basic geology courses which are at once "cultural" and "pre-professional". These programs, it seems to me, outline the areas within which the Association has had, and always will have, a unique function, and in which it can render its greatest service.

This is not to imply that no changes are discernable in the future. Changes assuredly will come, but probably these will pertain largely to extending ever more widely those services which are peculiarly the Association's own. I should like to suggest that the Association can hardly hope to realize its fullest possibilities in connection with these services unless it becomes formally affiliated with the American Geological Institute, and that the time has come for requesting an affiliation which would publicly recognize a kinship of purposes which has existed ever since the Institute was founded, and which, in the interests of both organizations, should be knit even more closely. There is also the obvious necessity for organizing the additional sections which will make the Association completely nation-wide in scope, and of direct aid to every geology teacher in the country. This obligation exists even though, since establishment of the Journal of Geological Education, the Association's influence is no longer limited to its immediate membership. Increasing the usefulness of the Journal is an opportunity which the Association undoubtedly will endeavor to realize. The issues which already have appeared reflect credit both on the Association and on Dr. William F. Read, who has given unstintingly of time and effort while serving in the double capacity of the Journal's first editor and manager. The modest covers of the early issues contain the first substantial body of papers yet published on the subject of teaching geology, and they provide a new and valuable aid to geological education. If only a beginning has been made, that beginning has justified the hopes of those who long urged that a publication of this type be undertaken. The Journal

merits the continued warm support of the Association and its friends, and financial backing which will make possible a wider circulation, and the publication of numbers issued at more frequent intervals, in larger size, and in printed format.

Other opportunities for the Association come to mind, but it is not my purpose to dwell further on this aspect of my subject.

In what I have said thus far it has not been my intention to give the impression that the members of the Association of Geology Teachers have been, or are, the only members of our profession deeply interested in the fostering of better teaching and in the other purposes for which the Association stands. If at times, ten to fifteen years ago, it seemed to those then active in the Association that theirs were voices crying in the wilderness, and that, outside of their own relatively small group, curiously little heed was given to the many problems of geological education, some of which appeared to be pressing, this situation certainly did not continue very long. For in the past decade growing concern with the same purposes which brought the Association into existence has been widely manifested throughout the geological profession—as evidenced, for example, by the assignment of committees of various other geological organizations to study specific and general educational problems; by the six educational conferences held between December, 1945, and December, 1947, under sponsorship of the National Research Council[3]; by the organization of the American Geological Institute (which for the first four years, 1948 to 1952, was most capably directed by Dr. David M. Delo, a charter member of the Association and now its retiring president); by the publication of several textbooks incorporating new and invigorating concepts of geological education; by the publication of

[3]Reports of these conferences were published in the Interim Proceedings of the Geological Society of America for 1946, 1947, and 1948.

wholesome non-technical articles like those currently appearing in Life; and by the conference held at Beloit College last week, sponsored by the National Science Foundation and having for its purpose a study of how the teaching and research effectiveness of college geology departments can be increased.

Beyond all doubt, the geological profession as a whole has evidenced its earnest desire "to foster improvement in the teaching of the earth sciences, ...to emphasize the cultural significance of the earth sciences, and to disseminate knowledge in this field to the general public". Probably, as Dr. Claude C. Albritton has suggested[4], this concern came about primarily as an outgrowth of events following the Second World War, "when the press of veteran enrollment threatened to destroy the better part of higher education, liberal and otherwise". Future historians of geology will be in a better position to appraise the causes and significance of this encouraging trend in our science. I shall attempt neither, since I only wish to observe that the initial purposes which brought about the establishment of this Association have become the common purposes of the geological profession as a whole and that, with respect to geological education, during the past decade as never before geologists have engaged in soul-searching and self-examination.

As a consequence of all this, the geology teacher need no longer operate in a vacuum, for there has been put on record a wealth of opinion to which he may turn for ideas representing almost every viewpoint concerning geological education at all of its various levels. Nor is it likely that this body of opinion will remain static for the literature of this field continues to increase, and we may count on it to reflect the changes in emphasis which must certainly result from constantly

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[4] "Historical Approach to the Problem of Training Geologists", by Claude C. Albritton, Jr. Field & Laboratory, Vol. XXI, No. 1, (June, 1952) p. 13.

changing conditions and requirements.

This is all for the good, and as it should be. Perhaps, having made the point that a neglected aspect of geology at long last is being accorded widespread attention, I should dismiss the subject. This, however, I am not quite ready to do; for in delving into the growing body of literature on geological education the thought has insistently recurred to me that a great deal has been said about teaching, but relatively little about teachers. Yet, in geological education as in any kind of education, the human factor is of paramount importance, and the most critical need will always be for outstanding teachers who are seriously devoted to their calling. However great strides geology may make with reference to such matters as defining the content of courses and curricula, and improving teaching techniques, such progress will benefit the profession little unless there is a continuing supply of the right kind of teachers.

Perhaps, I thought, neglect of the role of the teacher in geological education simply reflects diffidence in dealing with imponderables, in appraising factors which, however real and important, are nevertheless as intangible as those which make up personality. Such diffidence seemed altogether understandable to me, as I considered the attributes of those teachers who, from my personal experience, I would consider great. For most of them might be taken to illustrate Emerson's dictum that that man is great who never reminds one of anyone else. Whereas one teacher succeeded because of the keenness of his thinking--his mind scintillating like a flashing sword, compelling the student to reason for himself and defend his ideas or have them struck from his hand--, another was no less successful by reason of his patience and understanding, his gentle perseverance; a third, because of the sober orderliness with which he marshalled his facts and brought them to bear on the problems of his specialty; a fourth, because his sheer exuberance of spirits and good humor were irresistable,

and students found themselves liking his formidable subject because they first liked him. No, I was not sure I could discover the common denominator, if any, among my own teachers; and while I might contend that the most important factor in good teaching was the teacher, I did not relish the prospect of having to characterize the successful geology teacher.

Providentially I was spared this necessity when the Journal of Geological Education published, in its current issue,[5] Dr. Charles Behre's paper on "The Geology Teacher", an address given almost exactly a year ago at the Boston meeting of the Association. In his delightful essay Dr. Behre affirms, in brief, that the geology teacher should possess the attributes of enthusiasm, or "gusto"; skill in speaking--that is, "the capacity for vivid expression and clear speech"; apperception, which includes the virtues of patience and tolerance; capacity for extra-curricular interests and skills; ability to inculcate logical, objective thinking (and the "factual empiricism and conscious tentativeness" which are basic to the thinking methods of most geologists and which Dr. Behre regards as "the most important broader concepts that the student in the liberal arts college can derive from his schooling"); and, finally, ability to maintain close contact with the science, by which Dr. Behre means that, while the good teacher need not be an outstanding research worker, "he must be enough of a continuing scholar to keep in close touch with his subject" and to "have the fervor that goes with independent thinking in his science".

I am more than glad to accept Dr. Behre's thoughtful portrayal of the geology teacher, and to forego any attempt to sketch one of my own. And although I believe that the earth sciences, like other subjects, have suffered at the hands of those who have engaged in teaching as a matter of expediency, with no intention of making it a career, I can nevertheless subscribe to Dr. Behre's implication that geology has

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[5]Volume I, No. 5, (April, 1953), pages 11-25.

had, and still has, its fair quota of teachers who approximate his ideal--that geology thus far has been blessed with "as effective a group of teachers as we have in this country".

But the question does arise in my mind, what assurance have we that this favorable situation will continue? For unless my observations have led me astray, colleges are finding it increasingly difficult to retain outstanding geology teachers, or to replace the veterans, as these are lost through death or retirement, by men of comparable stature. Granted that the effective teacher has always been a bird of sufficient rarity to be hard to find, catch, and keep, nevertheless it seems to me that only in recent years have there come to my attention so many instances of teaching positions which have all but gone begging; only in recent years have so many of our colleagues, with the attributes which Dr. Behre ascribes to the successful teacher, left the teaching field in favor of alternative lines of endeavor; and only in recent years have so many promising young graduate students of my acquaintance who intended to become teachers turned elsewhere when, having earned their higher degrees, they reached the time of decision.

If I am not simply an alarmist, and it is actually true that many younger geologists especially qualified to teach are for one reason or another being drawn into other fields, that is indeed a serious matter. For the continued deflection of promising teachers must inevitable impoverish geology by leading to inferior instruction (the very situation we have been trying to combat) and, therefore, the recruitment of fewer new men of high calibre (a problem which has always been of concern to our profession, and which is now acutely aggravated by the present shortage of manpower).

Detailed analysis of this problem would exhaust my time and your patience, and therefore, in the best traditions of the Association, I shall merely sketch the problem as I see it, and leave it with this group

for the fuller consideration which would seem to be in order at some appropriate future time and occasion, if the membership shares my conviction that something should and can be done about the situation.

The problem is not simple, either as to causes or solutions. The most obvious factor which has operated to place teaching at a disadvantage is, of course, the economic. It is all too familiar to the teacher, who is continually confronted by the question of how long, in fairness to the needs of his family, he can afford to stay with educational work, however much he may prefer it, when he can so readily increase his income by turning to other fields of endeavor. It is equally familiar to the college administrator, who sees it outlined against the dark background of dwindling income from endowment and other traditional sources and mounting educational costs of all kinds.

I allude to this aspect of the problem only long enough to point out that, with respect to improving the situation, geology may have distinct advantages over many other fields. For at a time when college administrators are seeking to bolster their financial position by appealing to industry--by asking that industry take cognizance of its debt to higher education by contributing to the support of the colleges--it would seem that geology ought to be in an exceptionally favorable situation. The mineral industries have already acknowledged their stake in the training of geologists by establishing many fellowships to aid outstanding students at the graduate level, and since this program continues to be expanded it has evidently proven to be a sound investment. This being the case, why should not these industries be interested also in giving tangible support to other aspects of geological education, as, for example, by the establishment of undergraduate scholarships and the endowment of professorships? To do this would be to get at the very source of the manpower problem in geology, since it is at the undergraduate level that the spark of interest is kindled which leads young men and women to choose a career. Such support, if extended on the basis of

the same strict regard for merit which has governed the awarding of graduate fellowships, might mean the retention of gifted men whom the teaching profession can ill afford to lose but who are now drifting away from the campuses; and it could contribute in no small measure toward insuring a steady stream of capable, well-trained young men and women into the graduate schools. I know that beginnings have been made in this area; I trust that we may soon witness a notable development of these beginnings.

But the economic factor is not the only deterrent which has operated to turn geologists away from teaching. Last week, at the Beloit Conference sponsored by the National Science Foundation, consideration was given to a number of other factors, and constructive suggestions were offered with reference to giving the college teacher greater freedom to engage in research, and improving the library facilities and equipment with which he must work; and repeatedly, at this conference, reference was made to the desirability of providing for attendance at national and international meetings, and for occasional leaves of absence during which the teacher might have opportunity for writing, traveling, or refreshing himself academically and otherwise by returning for a period to the stimulating atmosphere of a university campus. I shall not dwell on these factors, since they will be covered in the report of the Beloit Conference which will shortly be made available to all who have an interest in it.

I pause before another aspect of the problem which to me seems to be of great importance. I refer to the multiplicity of demands made upon the college teacher, over and above those of teaching, in the excessively complicated life which has developed on most college campuses. To be sure, teaching becomes a varied and absorbing occupation under these circumstances, but it can become difficult to the point of frustration. My memory goes back to a searching analysis of this problem presented by Dr. David Delo at the first meeting of the Association of Geology Teachers. In his talk, which might have been entitled,

"The Dilemma of the College Geology Teacher", Dr. Delo analyzed the problem confronting the young instructor, whose entire training, in all probability, has been pointed toward one objective, that of preparing him for research, but who, as a college teacher, finds himself involved in so many other responsibilities that the pursuits of scholarship at times appear almost secondary, and a research program may be all but crowded out entirely.

Toward the distractions which ceaselessly tear him away from those interests to which he would like so very much to give himself whole-heartedly, the teacher may react in various ways. I think, for example, of one teacher who devoted years to building up a department, only to conclude at last that--as he put it to me--"Having lost whatever professional reputation I ever did have as a geologist I might as well get out of the field"--and being a man of action he did exactly that, to the great loss of our profession. Or the teacher may conclude, as probably most of us have done, that in the "maddening maze of things" which compete for our attention we cannot do and be everything but must ceaselessly appraise values; we must reject and select, and try, as best we can, to put first things first--which, inasmuch as we are teachers, certainly means giving most of our time and our highest loyalties to the teaching and counseling which are the very heart of our work, and which means also acceptance of the corollary fact that we may have to learn to be content with whatever margin of time remains for our personal enterprises, however cherished these may be.

I know of instances in which this factor has discouraged geologists from choosing an academic career, or from staying with it after a trial. In such instances I believe that a reduction of teaching load would be a salutary change, though I do not for a moment subscribe to the view that that teaching post is nearest the ideal which involves the least amount of teaching. The drain on one's time and energy made by the host of ancillary duties which necessarily

go with maintaining a geology department should certainly be taken into consideration in connection with determining what is a reasonable teaching load.[6] At last week's Beloit Conference, teaching overloads loomed as one of the foremost problems in connection with improving the teaching and research effectiveness of our college geology departments. At some future meeting the Association of Geology Teachers, too, might well give consideration to this question, one which, to the best of my recollection, has not thus far engaged its attention.

There is, finally, a factor which I would pass by, were it not that it has repeatedly come to my attention during the three decades I have been a teacher. It concerns the problem which confronts many young geologists who, at the conclusion of their graduate study, ask--as many of us once asked--"What choice of work shall I make?" Not that these young men and women face as many or diverse alternatives as those enumerated in the old nursery rhyme, "Rich man, poor man, beggerman, thief; doctor, lawyer, merchant chief." But they may be in the by no means easy position of having to decide between opportunities in, let us say, industry, government, and education; and among these students I have sometimes encountered the viewpoint which one of them expressed to me quite bluntly by saying, "Of course, practicing geology in industry or research is fundamentally more important than only teaching it." Perhaps it was much the same viewpoint which prompted a counselor in a graduate school to advise another young geologist not to accept a

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[6]See reference to this subject in the report on the "Geology Curriculum in the Liberal Arts College", issued jointly by the Committee on Geological Education of the Geological Society of America, Committee on Curriculum and Standards of the Association of Geology Teachers, and Committee on Geological Education of the American Geological Institute, Interim Proceedings of the G.S.A., 1950, Part 2, p. 13.

certain college teaching offer because, as he put it, "If you go there you'll probably do nothing but teach, and we'll never hear from you again".

A self-evident comment to make, in this connection, is that choice of a teaching career need not and should not wholly exclude other alternatives, such as service to industry and research. Indeed, it is one of the intriguing and distinctive features of geology that teachers in this field may, as it were, "move laterally" by making excursions into various areas of endeavor involving the practical applications of their science--and their teaching will be made all the more effective for such digressions, so long as it does not become secondary to them.

As for the comparisons involved in the remarks quoted, I would only say that I have never felt constrained to argue about the relative importance of the various choices open to those who elect earth science as a career, for frankly I have not the slightest idea which one of them is the most important. Rather, I have simply urged the point of view that all of them are important, and that any field of endeavor in our profession is worthy if one but makes it so. The only thing I would insist on as being more important than anything else is that each young man discover the particular specialty for which he personally is best suited.

Conceivably in some instances--probably the minority of instances--that specialty will be geological education. If it be so, let the man give himself whole-heartedly to his teaching, in the spirit of Chaucer's Clerk, who would "gladly learn and gladly teach". Let him not be apologetic about his choice, or troubled by misgivings which stem from apprehension lest he has chosen a field of service less important than others. And let those of us who are teachers frankly recognize that we have not only responsibilities but also opportunities and privileges all our own, for while we must be students of our subject first, we must be students of humanity first and last; and while we

can never afford to lose sight of the importance of our teaching, or the necessity of striving ceaselessly to improve it, we must realize that even more significant obligations may await us outside the classroom or laboratory, where, as counselors, we are called on to deal with human values and to help shape the lives of those who seek our guidance, not only on scientific questions, but with respect to the many other difficult problems which confront young people in these troubled times.

The title of these remarks, "The Estate of Teaching in Geology", may sound ambiguous to some because it employs the quaint word "estate" and furthermore uses it in an archaic sense. However, I chose this word advisedly, because none other seemed to serve my purpose so well. For "estate" is not quite synonymous with either "state" or "status" in that it carries with it the implication of a condition which is above the ordinary or commonplace, one which is of "exalted rank or dignity". That, it seems to me, expresses the connotation which is, or should be, linked with teaching. They also serve who "only" teach, and teaching, too, is a high calling. Of that, all of us at times need to be reminded. And if we ourselves are fully persuaded with respect to the significance of our work, others will find our attitude sufficiently contagious to insure that there will always be those who will willingly and effectively carry on the educational traditions of which we, in our times, have been the stewards. The future should then take care of itself.

THE ASSOCIATION OF GEOLOGY TEACHERS--A JANUS'-EYE VIEW[1]

Percival Robertson
Principia College

In classic times, so I am told, they sometimes set up highway markers capped by a bust of Janus, the two-faced god who had the ability to look backward to the past and forward to the future. This paper is some such sort of highway marker. It opens with a more or less fanciful prologue:

Scene I

Setting: a small mid-western college town--prosperous, energetic, conscious and proud of its local institution of learning. It is late afternoon. At a desk in a corner of the geology laboratory in Newton Hall, the science building, the geology teacher sits at his desk silently musing. His last student has departed. "I wonder if that is the best way that subject could have been presented? It is the way I learned it and I brought in the latest developments that I have had the opportunity to read, but still it seems to me that the method of presentation could be better. I wonder what they are doing in other colleges?" Lights out.

Scene II

Similar setting: another laboratory in another college. Another teacher. It is directly after lunch and he is trying to get some specimens together for a class due in half an hour. He thinks, "I wish I had some better barite samples, and that suite of copper minerals looks pretty nearly worn out. I wonder where I could get some more--for nothing, that is! My appropriation is exhausted. There must be

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[1]Read at the annual meeting, Central Section, A.G.T., Kent State College, Kent, Ohio, April 18, 1952.

some geologist in some college that would gladly send me the surplus he has available. I've got some beautiful suites of Ordovician and Silurian fossils that I would gladly trade to improve my mineral collection." The thinker is interrupted by a jangling bell and a mad rush of students.

Scene III

Another college town. Another one-man geology department. It is late at night. The teacher speaks to himself. "How am I going to manage this problem of field trips? Wish I knew what others are doing. Wish I could get in more research, but where could I find the time or the appropriation? Oh, how I'd like to discuss some of these problems with someone! Jim, my colleague in chemistry, is a good scout; he has good ideas on teaching; but still he is a chemist and doesn't know the first thing about geology. Why don't we geology teachers get together and talk about the problems of teaching our subject? It would improve our teaching. Jim says the chemistry teachers have an organization, a division of the American Chemical Society. He attended two years ago when it was meeting in our nearby metropolis. He says he got a lot of good ideas and met some men from other one-man departments..." The chapel bell tolls one.

If there should be any resemblance between the above fanciful scenes and real life it is <u>not</u> coincidental. Prior to 1937 the desires and aspirations implied were doubtless repeated over and over, and not only in small colleges. Then in 1937 something happened! The speaker did not have the privilege of being present at the important event, and so with permission he is quoting from the account of it given by his good friend Fritiof Fryxell in Volume I of the <u>Proceedings</u> of the Association of College Geology Teachers.

"Appropriately enough, the Association of College

Geology Teachers had its beginning in the field.

"In a sense it was an offspring of the Fifth Tri-State (Illinois, Iowa, Wisconsin) Geological Field Conference, held October 2 and 3, 1937, in an area classic in geology, southeastern Wisconsin. At noon of the second day of the conference the final stop had been made to examine the reefs of the Racine formation exposed in the Fuller Quarry at Wauwatosa, and the group of some 200 geologists had for the most part already scattered. It seems nothing short of providential that the last stragglers to leave the quarry should have been Dr. Neil A. Miner of Cornell College, Dr. M. E. Wing of Beloit College, Dr. L. R. Wilson of Coe College, and the writer--all teachers of geology in middlewestern institutions. (We had been associated throughout the field conference but had not met as a group until now.) Identities once established, a veritable outburst of questions followed--long suppressed questions relating to problems which, we knew, must confront us all. But for the impatient and hungry students waiting for us outside the quarry, we would have gone into session then and there. When Dr. Wing declared, 'We must get together again for a real session!' he spoke for us all. At the rim of the quarry we hailed Dr. David M. Delo of Knox College, just as he was about to leave, and added him to our circle. We had not been together fifteen minutes when we disbanded, but we went our respective ways with the definite agreement that before another year had elapsed we would meet again. The writer was asked to arrange for this.

"Subsequent events are a matter of record. On Friday, May 13 (let no man accuse geologists of superstition), Augustana College had the privilege of acting as host to the enthusiastic group of geology teachers who assembled at Rock Island, Illinois. After a day memorable for the intensity and earnestness of its deliberations, this group effected permanent organization as The Association of College Geology Teachers, and accepted the invitation of Cornell College to hold the 1939 meeting at Mount Vernon, Iowa.

"The Augustana meeting proved all too short for anything but an introduction of the subjects presented by men who up to this time had been working largely alone, with little opportunity for ascertaining how problems similar to their own were being met by colleagues at sister institutions. Yet this first meeting seems to the writer in retrospect the most helpful experience in his years of teaching; and he has already found opportunity to apply more than one of the constructive suggestions that grew out of it. Probably all who were present similarly profited. There is every reason to believe that future meetings of the Association should continue to make for increased professional solidarity in our ranks, the strengthening of our respective departments, and the attainment of new and more uniform standards in our teaching."

That meeting at Augustana proved so successful, and met the needs of those who attended it so effectively, that annual meetings followed regularly for the next four years. A constitution prepared by Fritiof Fryxell and David Delo was adopted in 1939 at Cornell College.[2] Papers were presented at the early meetings on such topics as field trips, equipment, curricula, visual aids, summer field courses, and "What the Graduate Schools Expect of Prospective Students". Probably the most important feature of the meetings was that each paper was thoroughly discussed. Everybody wanted to ask questions. It seemed as though, in the brief two days together, each teacher attending had a chance to unburden himself of a year-long accummulation of questions.

At many of the meetings a short historical sketch of the development of the geology department in the host college was presented.[3] Some departments had long records of service in their respective colleges.

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[2]Published in the Proceedings of the Association of College Geology Teachers, Vol. 1 (1939).

[3]Proceedings of the Association of College Geology Teachers, Vol. 2 (1940), Vol. 3 (1948).

We learned, for example, that plans for the science building at Beloit, and for the geology department library, were drawn up by Thomas C. Chamberlin when he was head of the department there.

At most of these meetings a field trip was conducted on Saturday morning. Field trips are, of course, the heart and soul of geology teaching. Teachers attending these meetings saw what other colleges had available, and they picked up valuable pointers on the way other teachers conducted field trips. Of course, every teacher had a chance to do some "highgrading" on his neighbour's pet collecting ground. The writer remembers particularly the remarkable Ordovician collecting on the field trip conducted by Hanover College at a slightly later date. The problems of transportation of students on field trips--conveyances, costs, and the legal responsibility of teachers and colleges conducting such trips, came up for fruitful discussion.

An early project of the Association was the compiling and eventual publication of a list of texts and references suitable for elementary students of geology, or for laymen. I presume every member of the organization at that time contributed something in the way of suggestions, but it was Lincoln Thiesmeyer who finally compiled the report and got it published in the Journal of Geology.[4] Reprints of the article were sold by the Association to teachers, students, and a wide variety of other purchasers. Our mailing list jumped from a few dozen to 160.

The attendance at meetings between 1938 and 1942 rarely exceeded a dozen. The 1942 meeting at The Principia College occurred five months after Pearl Harbor, and yet about a half dozen geology teachers felt that what they gained from the meetings was so important that they assembled and discussed what their departments were doing and expected to do in connection with America's war effort.

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[4] Journal of Geology, Vol. 51, No. 4 (May-June, 1943) pp. 276-283.

During the war years members of the Association were scattered to the four corners of the earth. The few who continued teaching found themselves giving courses in military map reading, meterology for pilots, geography, and the like. Even if the government had not clamped on travel restrictions, it would have been impractical to have had annual meetings. Still, those who had been most active continued to feel an interest in each other, and so newsletters, which described the activities of the members, were distributed from time to time. One such newsletter, dated February 20, 1943, contained notes about eight members of the tiny group. Several were in Washington; one was in the Philippines; one (a lady) was doing petroleum work in Texas; and so it went. Most of the Association's income during these lean years (1943-46) was provided by the sale of reprints of the book list.

One important geological event of the war interval was a meeting at Fort Worth, Texas, on April 10, 1943, to discuss the organization of an association which has since grown into the American Geological Institute. At that initial meeting there were duly accredited representatives from the Geological Society of America, the American Association of Petroleum Geologists, the Society of Economic Geologists, the Society of Economic Paleontologists and Mineralogists, the National Research Council, and the Association of College Geology Teachers. Lincoln Thiesmeyer served as our representative, and at the meeting was elected chairman of the committee to formulate the purpose of the proposed organization. The Association of Geology Teachers therefore feels that it did its part in helping establish the Institute.

The first post-war meeting of the Association was held at Knox College in Galesburg, Illinois, on May 10, 1946. It was an inspiring occasion--the old group (with some new members, too) getting together again after a four-year lapse that almost exterminated the young idea. Many things were discussed, but two decisions were of lasting importance: (1) Correspondence during the war years had clearly indicated that there

were many university teachers interested in our organization, and so we decided to open up the membership to all interested in our basic purpose and dropped the word "College" from the name of the organization. Since then it has been called the Association of Geology Teachers. (2) It was decided at this meeting that it would be highly desirable for the young organization to have a regular periodical. "Proceedings" had been issued somewhat irregularly. The name "Journal of Geological Education" was adopted at this time and a committee appointed to investigate both the cost of publishing such a journal, and possible sources of revenue. The same committee was to initiate action to bring the Proceedings up to date.

The meetings of 1947 and 1948 were at Milwaukee-Downer College in Wisconsin and Hanover College in Indiana. Attendance at these meetings was double what it had been previously. Another indication of growth was that at each of these meetings papers by geologists from large universities were presented. At the meeting in Milwaukee, Arthur Howland of Northwestern University spoke on "What the Graduate School Expects of the Undergraduate". At the meeting in Hanover, Miss Lou Williams (now Mrs. Thornton Page) spoke on "Geology in the Physical Sciences Course at the University of Chicago".5 The ideas expressed in this paper are still a source of inspiration to the writer.

The discussion following Dr. Howland's paper is worth recalling as an example of a beneficial exchange of ideas. The speaker had pointed out certain subjects which graduate schools wanted the student to know when they came, and certain others, including economic geology, which he thought could probably be better taught in the graduate years. In the discussion, one of the college teachers pointed out that it was a course in economic geology that really inspired his

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5Proceedings of the Eighth Annual Meeting of the Association of Geology Teachers (1948), pp. 3-6. Reprinted in the Journal of Geological Education, Vol. 1, No. 3 (April, 1952), pp. 25-33.

students to dig deeply into geology for the first time because they felt that here they were really getting something practical. The presentation of the two sides of the question, the undergraduate and the graduate, did much to bring about better understanding.

1949 saw a marked departure. The Association met for the first time as the guest of a large university. Some thirty members assembled in Rosenwald Hall at the University of Chicago and had the opportunity of looking in on some of the laboratory projects being conducted in this beehive of geological research. The total membership at that time was recorded as 75. It may be significant that at this first meeting in a university the paper which provoked probably the greatest amount of discussion was one by Ben Hur Wilson of Joliet Junior College, in which the problems of teaching geology at the high school level were presented. The description of what was being done in Joliet Township high schools alerted the group to the fact that there were only a few high schools that had geology courses, even though the subject was one eminently suited to high school curricula if proper teachers could be secured and public interest aroused.

In the spring of 1950, at the University of Illinois, the symposium type of meeting was introduced. All the papers at one session dealt with various phases of the teaching of mineralogy. The next year at DePauw University the teaching of historical geology and paleontology at the undergraduate level was discussed. The emphasis at all meetings was on the ideas we could share and carry away that would make all of us better teachers of geology.

About this time reports came from the east that many of our members there were considering getting together to hold the same sort of meetings that had been held in the midwest. In November, 1950, as a by-product of the annual G.S.A. meeting at Washington, D.C., the Eastern Section of A.G.T. was organized, Ralph Digman of Harpur College being elected as president. The first annual meeting of the Eastern

Section was held on April 20, 1951, at Lafayette College, Easton, Pennsylvania. A feature of the Association's meetings that has always appealed to teachers is that they have been small meetings, held at not too great a distance from one's own college, and where there was ample opportunity for discussion and questions. So long as the Association continues in this policy, opportunity to serve many teachers will continue and increase. In other sections of the country geology teachers are thinking of organizing other sections.

In March, 1951, the idea born in 1946 came to fruition. The first issue of the Journal of Geological Education appeared under the energetic editorship of William Read of Lawrence College, Appleton, Wisconsin. With a present circulation of about 200, its success and permanence seem assured.

A history that is composed exclusively of backward glances is dull at best, and of little value. We trace the path traversed that we may see more clearly whither we are going. In the 15 years since its inception, this organization has grown from five to one hundred and fifty in membership. The increase in numbers, so it seems to the writer, indicates that the Assocation is filling a need long felt. It is recognized that most of the larger geological societies have had committees and groups working on ways and means to improve geological education. All of these efforts have been fruitful and beneficial to geology teaching.

More sections of the A.G.T. are bound to come into being. Meetings of the National Association, organized in November 1951, will probably continue to be held concurrently with the meetings of the G.S.A. These meetings will undoubtedly serve the geology teachers who can get to G.S.A. meetings. The Association should continue to provide many small group meetings with plenty of discussion wherever geology teachers can conveniently get together. We should keep in mind continually the needs of the teacher in the small

school, operating on a small budget, and frequently with a salary that will not stand the added burden of a long trip. The university man benefits from these meetings, too, but he usually has more opportunities for contacts than the man in the small college.

Perhaps at no distant date the Association will hold meetings concurrently with the A.A.A.S. and the A.A.P.G. These organizations attract a large number of geologists, many of whom are teachers.

One question that will almost inevitably be raised in an organization of this sort will be that of standards for geology departments. This question was discussed by representatives of several geological societies at the G.S.A. meeting in Ottawa in 1947.[6] It was decided then to take no steps. This was undoubtedly wise. But someone will bring it up again. Someone always does. And the writer would like to drop here one word of advice in the hope that it will be repeated at such a time. It seems to me that the whole question of whether we should or should not have standards will depend on the spirit and purpose behind the project. If some group undertakes to set standards that all schools must follow if they are to have their graduates considered as properly trained, the result might conceivably be valuable. But we have so many minimum standards of this type set up by so many accrediting agencies. If, instead, a set of standards could be set up, expressing ideals--ideals that are possible of achievement even in little places--these would be valuable indeed. A struggling teacher with high hopes and aspirations, working in some inconspicuous school, could take a statement of such standards to his superior officer and say, "Here are some standards that geology teachers in other schools think are desirable. What can we do to more nearly approach these ideals? We don't have to in order to be

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[6] Interim Proceedings of the Geological Society of America, Part 2 (1948).

accredited. Our graduates, if they are really worthwhile young people, and if we give them the best we are now able to give, will be accepted in graduate schools. But we can, and we should, do more for them, and if we can bring ourselves more nearly in line with these standards, our students will be getting training more nearly comparable to that given in the best schools. If they continue their studies in another institution they will not feel themselves at a disadvantage, because we shall have done for them more nearly what the best schools do." If the Association could set up standards motivated by such objectives, I believe it would benefit many.

What are some further opportunities for the A.G.T.? Possibly a study of the equipment needed by practically all geology departments--such as trays, storage cases, and the like--could discover information that would work for economy and efficiency throughout the field. Perhaps some plan of cooperation in research would prove beneficial by providing the colleges with added opportunities and the larger research centers with more cooperating workers. Many geology departments in the smaller schools find great difficulty in collecting adequate libraries. It is our hope that more and more colleges will establish geology departments. It would be unfortunate if they were deterred from making such a decision because of difficulties in building up adequate libraries. Studies of all sources of publications, especially such publications as out-of-print numbers of state and federal surveys, would prove of great value to colleges now struggling to build their geology libraries, or contemplating such a struggle.

From the present viewpoint, the opportunities of the Association of Geology Teachers to improve the teaching of geology in America are limitless.

TOPOGRAPHIC MAPS FOR THE "SCIENCE CREDIT" COURSE

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The "science credit" student in physical geology commonly has the role of fugitive from the college science requirement. Often his presence is explained by the comment, "I had to take something for a laboratory science." The teacher's job is, therefore, complex. He must help a group of semi-interested people discover the fascination of landforms; he must provide them with illustrations of the scientific approach in geomorphic analysis; above all, he must give the students a basis for life-long appreciation of landscape. Each student will gain a great amount of satisfaction from his brief experience in geology--provided he does not associate the laboratories with an endless procession of similar appearing maps, on which some brown lines depict unfamiliar hills and valleys.

One easily-made addition to each topographic map exercise will add flavor to the landforms and should help draw attention to the geomorphic factors. It is not difficult to choose a quadrangle in which landforms have been controlling factors in a human drama or an absorbing adventure story. A printed synopsis of the historical event or literary background involved may be distributed with the map exercise, or the material can be presented in a discussion at the beginning of the laboratory period.

The Antietam quadrangle (Md., Va., W. Va.) is a classic map for the illustration of mature stream topography, adjustment of landforms to dipping sedimentary beds, and for entrenched meanders, windgaps, and watergaps. All of these features are of immediate interest to certain fortunate students who have a liking for geomorphology; to a great many others they are mazes of eye-straining contour lines in an obscure area--there is no apparent "life" or human significance

to the map. But there is "life", as the introduction reveals. Antietam has a distinctive place in American history. There has been adventure on the map. The landforms were of great importance to the armies who fought for control of the region in 1862. Federal forces had been beaten at the second battle of Bull Run; a large scale invasion of northern territory was under way; and the capitol at Washington was under direct threat. Harper's Ferry and Maryland Heights, strategic positions within the quadrangle, fell before the Confederate advance. The campaign to save Washington from siege developed within the map area. Union attacks forced the Confederates westward over Catoctin Mountain and across Middletown Valley, and there were encounters in Crampton's Gap, Fox's Gap, and Turner's Gap. The determined Confederate stand in the hills between Sharpsburg and Antietam Creek took place in the northwest quarter of the quadrangle. The battle of Antietam centered about points shown on the map, including Dunkard Church, Piper's Lane, and Bloody Lane. Burnside bridge carried important Union reinforcements into the battle.

If the student can become interested in Antietam's historical significance, he should also gain interest in the map itself. Similar combinations of geologic and historical interest are found on the Vicksburg and Gettysburg quadrangles.

Topographic profile exercises can be made more intriguing by choosing areas of extra-geologic interest. A profile across the Little Bighorn River can be made to show points of interest on the Custer Battlefield quadrangle (Montana).

Pioneer trails add history and adventure to many good laboratory maps. The Scott's Bluff (Nebraska) quadrangle, with its distinctive badland topography, shows portions of several such routes. The Cumberland Gap quadrangle (Ky., Tenn., Va.) includes topography resulting from a plunging syncline and a large thrust fault, a topographic record of stream piracy, and, as an added point of interest, part of Daniel Boone's

wilderness road.

Gold rush areas are associated with distinctive landforms. On the Furnace Creek quadrangle (Calif., Nevada) there is typical basin and range topography and there are some easily discerned triangular fault facets. On the same map are the famed ghost town of Rhyolite, several lost mine areas, and the background for a number of Death Valley legends. Of special interest to the more imaginative students is the Florence quadrangle (Arizona), with topographic features which are of significance in the Lost Dutchman mine legends.

Among maps which illustrate submergent features, the Nantuckett quadrangle (Mass.) has historical flavor and shows baymouth bars, bayhead beaches, and sand dunes.

There are landscape descriptions in American literature which add color to certain quadrangle maps. The Concord quadrangle (Mass.), in addition to its glacial drift features and Revolutionary War interest, displays topographic features which are well-known to all who have read Thoreau's Walden. A. B. Guthrie's The Big Sky contains passages describing the topography of the Grand Teton quadrangle (Wyoming). For those students who enjoy the historical novels of Kenneth Roberts, there is topography steeped in adventure on the Ticonderoga quadrangle (15-minute series, Vermont) and the Memphremagog quadrangle (Vermont).

At Idaho State College, the background material pertaining to topographic maps is presented on typewritten sheets as illustrated by the following example:

MEMPHREMAGOG QUADRANGLE, VT.

In his novel Northwest Passage, Kenneth Roberts has given an excellent description of this country with its maturely dissected mountains, moist climate, and changes wrought by continental glaciation.

This is how the area looked to one of Rogers'

Rangers", a body of frontier raiders returning from Canada during the French and Indian War:

"If there is worse country--for men in a hurry--than that to the east of Memphremagog, I have yet to see it. Ordinarily, during storms in a forest, there are signs to indicate points of the compass; and if a brook or river can be found, one needs only to go up it--or down it, as the case may be--in order to go farther on his way.

"Memphremagog isn't like that. Its hills and mountains are packed together like fish-balls on a platter; and the wind, blowing between two hills and striking together, is twisted about so that it blows in circles. Thus rainstorms, instead of hitting trees properly and causing moss to grow on the northerly side, strike from all directions at once. As for the water courses, there are brooks within half a mile of each other, flowing in four directions at the same time. Streams turn at right angles for no apparent reason, or make almost complete loops; and the valleys through which some of them flow are so deep and so involved that they seem to have been planned and dug by some insane god."[1]

Local relief of this area is approximately 2300 feet, with elevation increasing toward the southeast, where the surface is underlain by the hardest sedimentary and igneous rocks. The topography results from complex bedrock structure, continental glaciation, and stream dissection.

The escarpment along Black River (southwest of Newport) reflects a faulted contact between weak limestones on the east side of the river and resistant phyllites on the west. Phyllite beds dip

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[1]From Northwest Passage, by Kenneth Roberts. Copyright 1936, 1937 by Kenneth Roberts. Reprinted by permission of the author and Doubleday & Co.

steeply to the west-northwest.

To the east of Lake Memphremagog, Dowling Hill and Shattuck Hill are hog-backs. The beds underlying Dowling Hill dip to the west; the beds underlying Shattuck Hill dip to the southeast.

The domical knobs from Elm Hill to Salem Hill, "fish-balls on a platter", are developed on a large granite mass. Clyde Pond, Derby Pond, Salem Pond, and Brownington Pond occupy depressions along the granite-metamorphic contact.

The general area has reached the mature stage of stream dissection, but the streams themselves are youthful--a result of continental glaciation. An earlier stream cycle left Barton Mountain, west of Willoughby, as a monadnock in granite. Glacial ice moved toward the southeast, as shown by Barton Mountain--a large "roche moutonnée".

Post-glacial uplift of the region is recorded by elevated terraces in the vicinity of Lake Memphremagog. One terrace level at approximately 700 feet elevation includes Indian Point and Lake Park. An older terrace, of approximately 1000 feet elevation, includes Pine Hill (east of Newport) and the general area south of the Clyde River to West Charleston.

For most male students in the Rocky Mountain West, additional comments on hunting and fishing conditions in topographic map areas provide an incentive to study the landforms. Such data are available from state fish and game departments, as in Idaho, where the type of fish stocked in specific mountain lakes is noted periodically.

Maps showing winter sports areas, also national parks sheets, are well received by most students. Currently active dam construction projects provide material for topographic map exercises. The Irwin quadrangle (Idaho) shows the topography around

Palisades Dam. Given the location of the dam (Calamity Point), and its approximate height (200 ft.), the student can sketch an outline of the lake which will form.

Variety in types of topographic maps will add to student interest. Several new series of U.S. maps employing color tints and shading to show relief can be used in laboratory work. Foreign maps--especially British, Swiss, Canadian, and Australian--provide good exercise material.

Lists of U.S.G.S. quadrangle sheets, colored and shaded relief maps, and foreign maps, which we at Idaho State College have found suitable from a combined-interest standpoint appear at the end of this paper.

Many of the suggestions given have been in use at Idaho State College for three semesters. Interest directly attributable to such efforts has been indicated by a large portion of each class. Among the remaining students, the lack of interest in topographic maps is accompanied by a distaste for history and literature; therefore, the approach given here cannot be offered as a complete solution to the problem of the "mid-afternoon slump".

Standard U.S.G.S. Quadrangle Sheets
(Numbers refer to bibliography)

Antietam, Md., Va., W. Va.
Topographic expression of folded bedrock structure.(9)
Civil War campaign.(6)(12)
Ballarat, Calif., Nev.
Basin-range topography; desert landforms.(1)
Death Valley--ghost town of Panamint.(3)
Furnace Creek, Calif., Nev.
Basin-range topography; fault scarp facets.
Mining boom camps (Rhyolite and Bullfrog).
Death Valley--Amargosa Desert.(3)(4)

Gettysburg, Pa.
Topographic expression of folded bedrock structure and intrusives.(17)
Civil War battlefield.(6)(12)(11)

Kings Mountain, N.C.
Piedmont topography; ancient peneplain; monadnocks.(10)
Revolutionary War battleground.(11)

Vicksburg, Miss.
Oxbow lakes; natural levees; floodplain swamps; yazoo streams.
Civil War campaign.(11)

Florence, Ariz.
Desert landforms; buttes; mesas.
Lost Dutchman Mine locale.(16)

Cumberland Gap, Ky., Va., Tenn.
Topographic expression of folded bedrock structure; thrust fault.(1)
Daniel Boone's Wilderness Road.(13)

Ticonderoga, N.Y., Vt. (15-minute series).
Topography on complex bedrock structure; post-glacial adjustment; abandoned erosion levels; lake benches.(2)
French and Indian War.(15)
Revolutionary War.

Scott's Bluff, Nebr.
Prominent erosional features; badlands.
Pioneer trails.(11)

Concord, Mass.
Post-glacial topography.
Revolutionary War.
Walden.(18)

Grand Teton, Wyo.
Alpine glacial features.(7)
The Big Sky.(8)

Memphremagog, Vt.
Post-glacial topography; ancient erosion surface with monadnocks; topographic expression of rock types; fault contact expression.(5)
Northwest Passage.(15)

Custer, Idaho.
Alpine glacial features.(14)
Fishing and elk hunting area--Stanley Basin, Salmon River Mountains.

Packsaddle Mountain, Idaho.
Pend Oreille Lake; glacial trough.(14)
Famous trout fishing area.
Leadville, Colo.
Alpine glacial features; moraine lakes.
Winter sports area.
Historic mining town of Leadville.
Irwin, Idaho.
Topographic expression of folded bedrock.
Palisades Dam project.

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(16) Storm, Barry, Thunder God's Gold, Southwest Publishing Company, Tortilla Flat, Arizona, 1945.
(17) Stose, G. W., and Bascom, F., Geologic Atlas of the United States, "Fairfield-Gettysburg Folio, No. 225", 1929.
(18) Thoreau, Henry David, Walden, Signet Books, New American Library, New York, 1942.

Tinted and Shaded U.S. Relief Maps

Clintonville, W. Va. (U.S.G.S. quadrangle sheet, shaded relief edition).
Topographic expression of folded bedrock.

San Francisco Bay, Calif. (International Map of the World, sheet J-10, 1:1,000,000).
Submarine canyon, fault valleys.

Death Valley, Calif. (Army Map Service, series V-502, sheet NJ-11-11).
Basin-range topography.

Waldron, Ark. (U.S.G.S. quadrangle sheet, shaded relief edition.)
Topographic expression of plunging folds.

Juneau, Alaska (Alaska Reconnaissance Topographic Series).
Submergent embayed coastline; glaciers.

Yosemite National Park, Calif. (U.S.G.S. quadrangle sheet, shaded relief edition).
Glacial features.
Explanatory test.

Foreign Maps

Canada[2]

Fort St. John, B.C. (national topographic series, sheet 94 A/2; 1 mi. = 1 in.).
Cuspate stream terraces.
Along Alaska Highway.
Victoria, B.C. (sheet 92 B/6; 1 mi. = 1 in.).
Submerged embayed coastline.
Lake Louise, Alberta, B.C. (sheet 82 N/8; 1 mi. = 1 in.).
Glaciers; post-glacial topography.
Spiral railway tunnels along Kicking Horse River.
Glacier National Park (2 mi. = 1 in.)
Kootenay National Park (2 mi. = 1 in.)
Mount Revelstoke National Park (1:125,000).
Yoho National Park (2 mi. = 1 in.)
Banff National Park (3 mi. = 1 in.)
Jasper National Park (two sheets; 3 mi. = 1 in.)
Waterton Lakes National Park (1 mi. = 1 in.)
Wood Buffalo National Park (8 mi. = 1 in.)
Prince Albert National Park (2 mi. = 1 in.)
Riding Mountain National Park (2 mi. = 1 in.)
Cape Breton Highland National Park (2 mi. = 1 in.)

Australia-New Guinea[3]

Milne Bay (Australian aeronautical map C-9; 1:1,000,000)
Fringing reefs, barrier reefs, atolls.
Townsville (Australian aeronautical map E-8; 1:1,000,000)
Great Barrier Reef, headlands, marine spit.
Barrow Creek (Australian aeronautical map F-6; 1:1,000,000; reconnaissance map).
Desert ranges and basins, playas, arroyos.

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[2]Obtainable from Map Distribution Office, Dept. of Mines and Technical Surveys, Ottawa, Ontario.
[3]Obtainable from Department of Civil Aviation, 522 Little Collins St., Melbourne, Australia.

Europe[4]

Ipswich, England (Ordnance Survey of England and Wales, sheet 87; 1 mi. = 1 in.)
Coastal plain shoreline in early maturity with cuspate offshore bar, tidal marsh, tidal river.
Interesting cultural pattern; Roman roads.

Argyll, Scotland (Bartholomew's "Half Inch" contoured series; Great Britain, sheet 47).
Submergent fiord coastline, glaciated highlands.
Linear expression of Great Glen Fault in lochs.
Fingal's Cave.

Scheidegg, Switzerland (Topographischer Atlas der Schweiz; 1:50,000).
Alpine glaciers and Alpine topography.
Jungfrau, Eiger, and Mönch.

Editor's Note

Correspondence with Mr. Peters regarding the foregoing paper has brought to light some additional aspects of the laboratory procedure at Idaho State College which will, it is thought, be of interest. The following paragraphs are quoted from a letter by Mr. Peters dated Sept. 8, 1953.

"Your mention of photographs or lantern slides to accompany the maps is in line with my own ideas. I have not, however, been able to collect enough good slides of the literary-historical areas chosen. As soon as I can summon enough energy to investigate sources, I intend to get some slides of such areas as Walden Pond, Ticonderoga, Memphremagog, and Gettysburg. With our national park maps we use Kodachrome slides purchased at some of the park headquarters.

"We have stereo-pairs of vertical air photos for some of the areas used in map exercises. Six folding stereoscopes are set up on two extra laboratory tables. During the past year students have taken a great deal

[4]Obtainable from major U.S. map companies.

of interest in this material. My source of information regarding stereo-pairs has been the A.G.I. special publication, 'Selected Aerial Photographs of North America'. Some of the quadrangles for which air photos are provided as supplements are:

Mackay, Idaho ---- glaciation, landslides.
Jackson, Wyo. ----- braided Snake River.
Pocatello, Idaho -- local geology.
Chief Mt., Mont. -- Alpine glaciation.
Harrisburg, Pa. --- Appalachian topography.
Vergas, Minn. ----- continental glaciation.
Mammoth Cave, Ky. - cavern cycle.
Point Reyes, Cal. - coastline topography.

"In regard to questions or exercises on special-interest maps: my practice has varied from semester to semester. One standard exercise has been to require a profile through an important area, with arrows pointing to landform types--for example, on the Antietam quadrangle, a cross section from the intersection of Hagerstown Pike and Pipers Lane through McClellan's Lookout and South Mountain to the center of Middletown Valley--vertical exaggeration x10; labels to show entrenched stream, folded sedimentary rocks, crystalline complex, etc. Questions follow concerning origin of windgaps, a watergap, and evidence of previous erosion cycles.

"Another approach has been to ask questions on specific features--for example, on the Vicksburg quadrangle, the origin of yazoo streams, points along river exposed to erosion, location of artificial and natural levees, and origin of specific ox-bow lakes.

"In general, I have not yet found a completely satisfactory method of presenting questions. I am still groping for an answer and may find one in time--say, by 1973. The Journal can be of great assistance to all of us in this respect. An exchange of teaching ideas will keep geology in its rightful position--as the most fascinating laboratory science in the curriculum."

PLASTIC MODELS FOR USE IN TEACHING CRYSTALLOGRAPHY AND OPTICAL MINERALOGY[1]

James R. Dunn and Milton Dwoncozyk
Rensselaer Polytechnic Institute

One of the most vexing problems to the teacher of crystallography and optical mineralogy is that of demonstrating clearly the relationships between optic directions, crystal form, and cleavage in minerals. Students seem to be able to comprehend the fundamentals of crystallographic and optic theory with a minimum of difficulty, but even the brightest student frequently lacks an adequate comprehension of relative orientations.

The use of block diagrams to demonstrate orientations is useful, but while obvious to the instructor, the crystallographic relationships are not always clear to the student. Opaque plaster and wooden models are most desirable to study form, but their lack of transparency is detrimental to the lucid visualization of the internal axes. An obvious answer to the difficulty is transparent models of minerals or generalized crystals. Glass models have been made under the direction of Dr. F. Krantz of Bonn, Germany, but although his models are excellent, they are expensive and rather fragile.

In an effort to solve the problem, students at Rensselaer Polytechnic Institute were given laboratory exercises in making transparent plastic models using Ward's Bioplastic. Because of their inexperience, the students' models were not entirely suitable, and also this work was too time-consuming to be continued

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[1]Presented at the joint annual meeting of the New England and Eastern Sections of A.G.T., Rensselaer Polytechnic Institute, April 3-4, 1953. Models similar to the ones here described, and prepared under Professor Dunn's supervision, are currently for sale by Ward's Natural Science Establishment.

as a student exercise. However, after two years of further experimentation, the authors have developed a technique for producing satisfactory plastic models for use in teaching crystallography and optical mineralogy.

The first completed model was for hornblende (Fig. 1). The crystal shape is simple, consisting of the 110, 010, and 001 forms. A very light-colored fluorescent pink surface through the center, parallel to the 010 form, represents the optic plane. Normal to the optic plane is an olive green thread representing the y optic direction and one of its common pleochroic colors. Lying within the optic plane are two black threads representing the optic axes, a yellow-green thread representing the x direction and its pleochroic color, and a dark green thread representing the z direction and its pleochroic color. Because the sign is negative, the optic axes are on either side of x, in this case at an angle of 75°. The a, b, and c crystallographic axes are not included because they are obvious from the external form.

From this single model a student is easily able to relate the crystal form to the principal optic directions and obtain a better understanding of the orientation of individual grains in a thin section. In addition, this model greatly facilitates the presentation of techniques for making block diagrams of other minerals.

Similar models of orthoclase, sanidine, microcline, anorthoclase, the plagioclases, and pyroxene would also have obvious value for instructional purposes. The models of the plagioclases particularly should be very useful because the problems involved in teaching universal stage techniques for the determination of the composition of plagioclase should be considerably simplified.

Other models have been made which relate the index ellipsoids to the optic directions and crystal form.

PLASTIC CRYSTAL MODELS

Photographs courtesy of Ward's Natural Science Estab.

Fig. 1
Hornblende, showing x, y, and z optic directions.

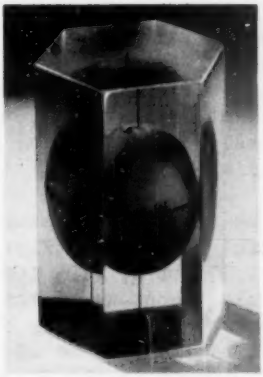

Fig. 2
Hexagonal crystal, showing uniaxial index ellipsoid.

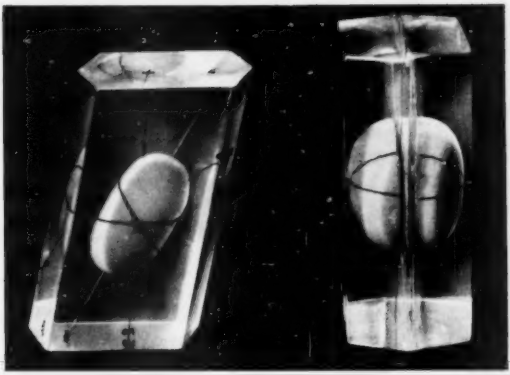

Fig. 3
Monoclinic crystal, showing biaxial index ellipsoid.

Models as shown above are about two-thirds actual size.

The uniaxial index ellipsoid of revolution of a positive hexagonal mineral (Fig. 2) shows the relationship of the circular equatorial section, and of course all sections parallel thereto, to the optic axis. The long axis of the ellipsoid is equivalent to an ϵ refractive index of 1.5, and the short axis, to an ω refractive index of 1.0. While the magnitude of the difference between the two indices is abnormally great in the model, the exaggeration serves to emphasize the essential characteristics of the uniaxial ellipsoid.

The triaxial ellipsoid of a simple monoclinic mineral is shown in Fig. 3. The lengths of the axes are 1.75 for z, 1.25 for y, and 1.00 for x. The two circular sections of the index ellipsoid with 1.25 diameter, representing the y refractive index, are drawn on the outside of the ellipsoid, and the optic axes, normal to the circular sections, are shown by two black threads. The x, y, and z directions are shown by red threads.

The principal problem in the construction of models like these is the preparation of a satisfactory mold for the external crystal form. The use of heavy cardboard, rubber, and other non-rigid materials results in warped casts, which necessitate a considerable amount of grinding and polishing. Glass is ideal, but molds of this material are disproportionately time-consuming to prepare. Entirely satisfactory results were obtained by the writers by soldering together small pieces of sheet metal, the ends of the mold being left open to permit removal of the cast.

The optic plane consists of a thin sheet of tinted plastic which is prepared first in a separate flexible mold. Before plastic is poured, appropriate colored threads are strung through the mold. After the cast has been cured, the optic plane is lettered, and a hole is drilled for the y-axis. If the model is to include an index ellipsoid, the halves of the ellipsoids (cast separately) are cemented to the optic plane.

Finally the optic plane is placed in the crystal mold; the y-axis is threaded through the sides; and sufficient clear plastic is poured in to fill the mold. Minor surface irregularities on the finished model are easily removed by polishing.